

# Internet Access to a Medical Case Repository for Teaching and Analysis

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## ABSTRACT

*The acute radiation syndrome is a rare disease. Teaching its treatment and the achievement of scientific progress require a sufficient number of accessible case histories. An information system for standardized recording of acute radiation syndrome case histories has been established in the framework of the World Health Organization Radiation Medical Emergency Preparedness and Assistance Network Centers. The information system has been realized in client/server architecture. The centers are able to access the database by easy to use graphical user interfaces via the Internet. Focusing on optimization of network traffic and flexible information retrieval the hypertext transfer protocol has not been applied. At the moment the system is tested on the campus of the University of Ulm before it will be installed at the other centers.*

## INTRODUCTION

The acute radiation syndrome (ARS) is a seldom occurring disease caused by accidental irradiation. Until now only 587 cases which had to be hospitalized due to the seldom occurring event of radiation overexposure are known world-wide [1]. Nevertheless, international organizations and government authorities appreciate the risk that humans might be involved in radiation accidents. The World Health Organization (WHO) Radiation Medical Emergency Preparedness and Assistance Network (REMPAN) centers, the European Radiation Protection Education and Training Course on Medical Aspects of Radiation Accident Management (ERPET), and the Oak Ridge Institute of Science and Education (ORISE) training course are exemplary activities in medical radiation protection on an international and national level.

During training courses, e.g., the ERPET and ORISE course, physicians are educated mainly theoretically on the diagnosis and therapy of the ARS. The case studies published in the literature lack enough detail to be used for training instead of real cases. An information system consisting of a database supplying a selection of standardized ARS case

descriptions and a tool to easily visualize ARS case histories is very valuable for teaching. A physician who is theoretically well trained but did not have the opportunity to gather practical experience can improve his diagnostic and therapeutic skills by studying exemplary case histories in such a case history repository.

Additionally the database will serve to gain new scientific insights and to improve and test diagnostic guidelines and treatment protocols for the ARS. For maintenance and retrieval performance reasons the case history repository is located on a central server. The information system can be accessed by specialized clients over the Internet.

## METHODS

The International Computer Database for Radiation Accident Case Histories (ICDREC) [1] has been built up for the purpose of standardized ARS documentation.

The original paper-based ARS case histories are documented in different languages using several alphabets. The reporting has neither been structured nor standardized. The case reports are dispersed all over the world.

A standardized reporting of ARS case histories has been achieved by the Clinical Pre Computer Proforma for the ICDREC [2]. Controlled vocabularies are applied for standardization, e.g., the international nonproprietary names are used for drugs. The core of the database is formed by case histories of the Moscow-Ulm Radiation Accident Clinical History Data Base (MURAD) [3]. The conceptual database schema has been developed applying Nijssen's Information Analysis Methodology (NIAM) [4]. NIAM is well suited when starting from paper-based documents populated with real data and leads to a conceptual scheme in third normal form. The database is now operational on an ORACLE7™ database server. It encompasses clinical findings, laboratory values, and medication.

Due to the decomposition of the patients' data caused by third normal form it is nearly impossible for a physician to locate the requested information in the database tables. Instead of working directly on the

database tables it would be an advantage to provide an easy to use graphical interface to the physician which supports the visualization of a patient's course. The physician has to choose the patients and the items that shall be visualized. The retrieval and the presentation on the display is performed automatically. The item list is obtained by filtering the data dictionary and the controlled vocabulary. The information what item to find in which table and how to display the data belonging to a particular item is attached to the item list. It is used by the client to formulate the queries and to display the results.

The ICDREC is realized in client/server architecture [5]. The bandwidth of the physical connection plays an important role for the interoperability. Dialog applications have to be carefully designed to operate over a bandwidth-limited telephone line or over congested Internet links. The routable protocol TCP/IP [6] principally facilitates access to the database server from everywhere in the Internet which is limited by a firewall to authorized clients only.

SQL\*NET<sup>®</sup> provides database access for the client applications to the ORACLE7<sup>™</sup> database server, encryption is available in this layer. Open database connectivity [7] enables the client software written in Microsoft<sup>®</sup> Visual C++ to establish a connection to the database.

Internet and telephone connections have a narrow bandwidth. Reducing the network traffic in general and in particular reducing the network traffic for dialog communication by replacing it, wherever possible, by batch transfer copes best with it.

When the client software is loaded it fetches the actual item list and patient list from the database server. Later the response time is by far better instead of retrieving the lists every time the user activates a list field. Each query sent from the client to the server to display a set of items returns a list. The client software creates a graphical presentation of these data. No network traffic is caused by zooming the display in or out because the data are cached on the client.

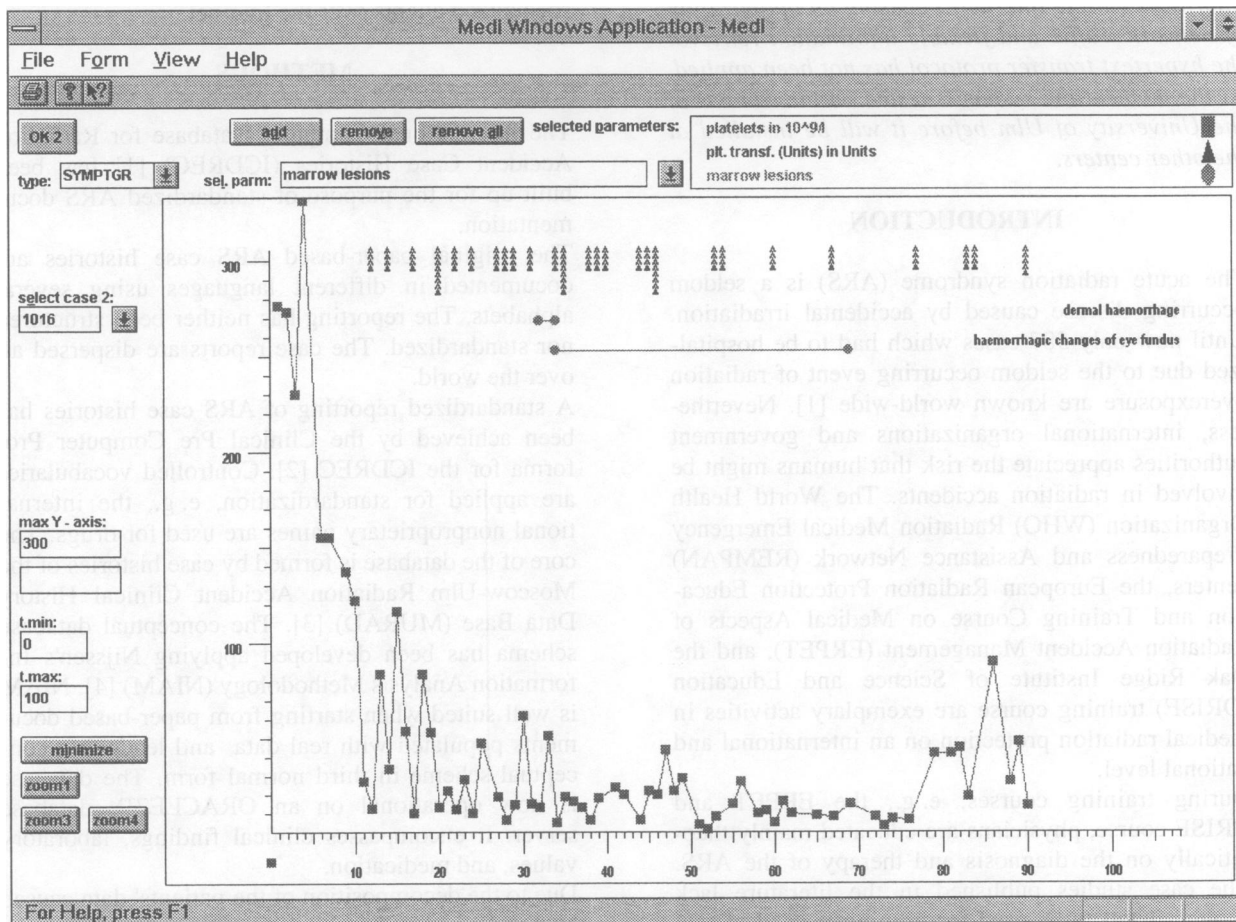


Figure 1: Display of platelets, platelet transfusions, and hemorrhage for patient 1016.

## RESULTS

At the moment 288 acute radiation syndrome case histories are completely recorded in the ICDREC. The case histories have been extracted from original case reports in China, Russia, Ukraine, Japan, and the USA,

The temporal course of 1532 items can be displayed. The different categories are:

- signs and symptoms, e. g., vomiting,
- sign and symptom groups, e. g., marrow lesions,
- administration of drugs, e. g., NEOMYCIN,
- administration of drug groups, e. g., antibiotics,
- laboratory values, e. g., course of platelets, and
- therapeutic actions, e. g. platelet transfusions.

Calling the graphical user interface on the client takes 30 seconds via a local area network (LAN) and 90 seconds with a 28 kbaud modem. Most of the time during this process is consumed to retrieve and transfer the information from the data dictionary.

Given the case a physician is interested in the following questions:

- Did a particular patient suffer from hemorrhage?
- Were the clinical manifestations correlated with a low platelet level?
- Have platelets been transfused?

The user displays the platelets, signs and symptoms related to the bone marrow, and the platelet transfusions to answer these question for case number 1016, see fig. 1.

To achieve this he first chooses the case number 1016. The selection of one item comprises two steps because of the high number of items. The user chooses the item category and then an item belonging to the category. To choose the item *marrow lesions* first the type *symptgr* is chosen in the upper left of fig. 1 and then the item *marrow lesions* is selected. The chosen item is added to the list of *selected parameters* located in the upper right of fig. 1. The selected items are displayed with different colors and are related to different geometric symbols for recognizing them on the canvas, i. e., rectangles for the platelets, triangles for the platelet transfusions, circles for the marrow lesions. The platelets as continuous variable are plotted as a graph. The platelets transfusions as discrete actions are marked by single symbols. The periods of hemorrhage are displayed as intervals. Patient 1016 showed hemorrhage at different locations.

The display of the chosen items including the data retrieval from the server takes 3 seconds via a LAN and 8 seconds with a 28 kbaud modem after clicking on the *OK2* button. Scaling the graph takes less than a second due to caching.

The physician can switch to a screen like in fig. 2 to compare four different cases for the same set of items by clicking on the *minimize* button. Each of the four cases in fig. 2 can be magnified similar to case 1016 in fig. 1.

The ICDREC has already been applied in the 1996 ERPET to demonstrate typical ARS cases in a very detailed manner to the course participants. The feedback was very positive.

The ICDREC is regularly used by the staff of the Ulm REMPAN center for scientific analysis. The Moscow REMPAN center intensively works on with a local replication of the ICDREC. At the moment the Internet access for Japanese colleagues is prepared.

## DISCUSSION

Several medical imaging groups have built-up medical case collections as teaching files on the World-Wide Web (WWW). Hypertext case repositories based on the hypertext transfer protocol [8] have been provided for radiology [9, 10] and nuclear medicine [11, 12]. Reasons to provide the case collections on the WWW are that film-based files are expensive to create and duplicate, multi user access is not possible, and they physically occupy considerable space. These problems resemble to the paper-based ARS documentation. The case descriptions and the images are stored on a HTTP server. Easy-to-use WWW hypertext browsers are applied as user interface. A case repository represented as a hypertext with limited pre-defined access paths is well suited for teaching and tutoring. However, it is not possible to select items by name and to display and compare their temporal course. The clinical data servers at the Columbia-Presbyterian Medical Center can be accessed using WWW [13]. The data are provided on a HTTP server.

A hypertext is not suitable to represent the information in the ICDREC. The physician needs a flexible access to the case history data. The user interface of the ICDREC is comparable to a viewer for electroencephalography data [14]. The electroencephalograph has the possibility to flexibly select a set of items and to compare their course over time. The electroencephalography system heavily depends on the LAN because of the masses of data to be transferred and displayed.

The common gateway interface (CGI) [8] in the HTTP allows access to other information sources than hypertext, e. g., databases. In principle it would have been possible to realize the user interface using CGI and WWW. The programming of list boxes to choose case numbers and items is much more complex than in an object-oriented language. The list

boxes have to be filled in close co-operation with the gateway located on the server. This causes network traffic and slows human-computer interaction down. Satisfying dialogue answer time have been obtained for the ICDREC by application of specialized client software. Disadvantages of the specialized user interface for the ICDREC are that it has to be installed individually on each client computer and that it must be provided for every single operating system. For instance, a Japanese radiation protection center intending to use the ICDREC cannot run the client software at the moment because they use Apple® Macintosh® computers, only.

JAVA™ [15] could be a mean to solve these problems in the future. In principle it should be feasible to implement the ICDREC user interface with similar effort and performance in JAVA™. The JAVA™ elements to build the user interface correspond to the Microsoft® Visual C++ elements. JAVA™ database

connectivity (JDBC) could be used instead of ODBC to access the ICDREC database.

Two questions will have to be clarified in the future:

- Who can access the ICDREC?
- Under which conditions can he access the ICDREC?

At the moment the contributors, either software or case histories, are drafting a contract to regulate the access. The use of the ICDREC for scientific purposes, the development of guidelines, and the training of physicians, e. g., ERPET course, will be free of charge for the contributors. Non-contributors will have to pay a fee to exploit the case repository.

Only wet data and no conclusions are stored in the ICDREC. The responsibility for the data and for the consequences using the data seems to play of less important role than compared with clinical practice guidelines.

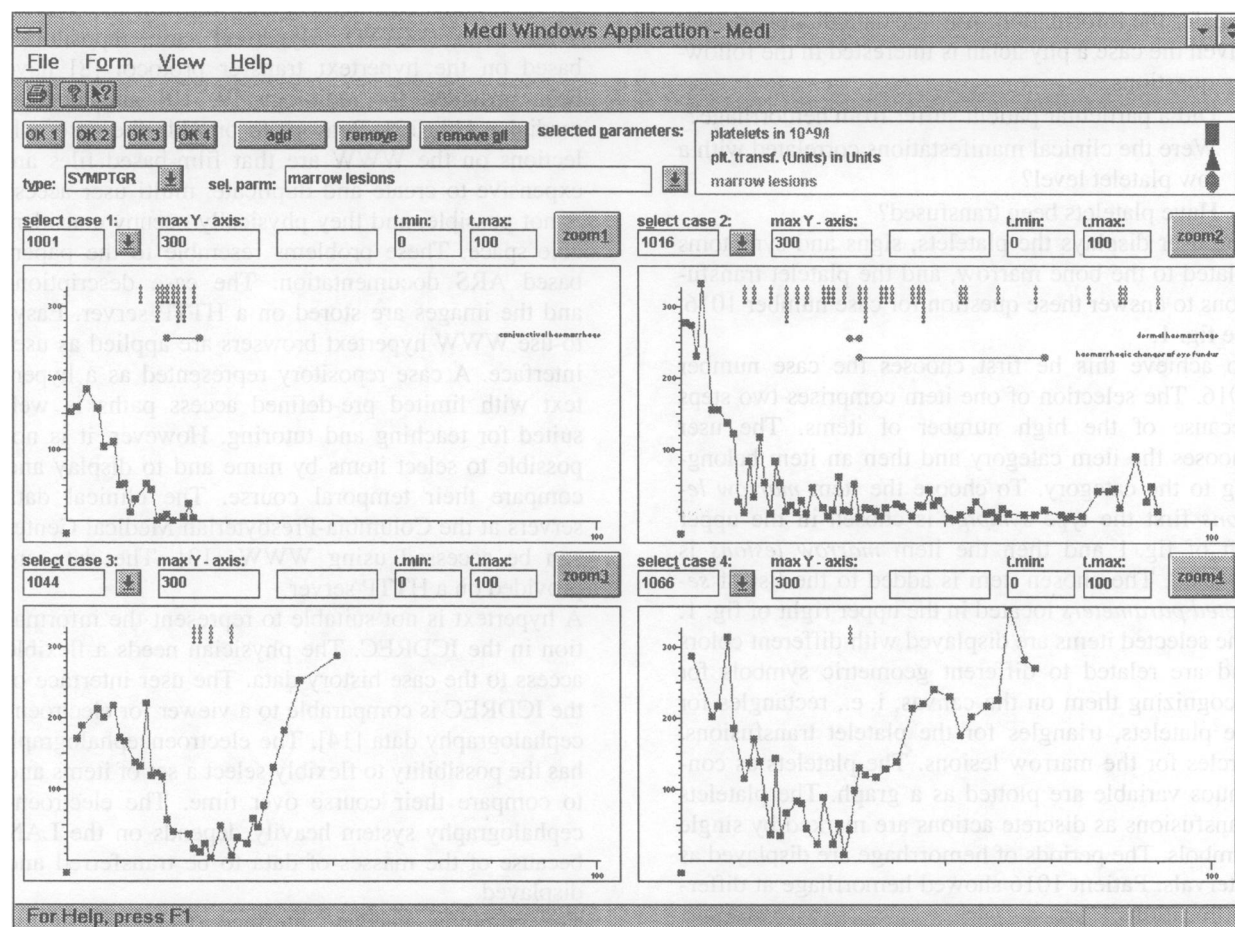


Figure 2: Display of three items related to hemorrhage for four patients.

## CONCLUSION

The WHO REMPAN centers have established the ICDREC as a medical case repository for the ARS. Physicians can easily access it from computers located both locally and elsewhere in the Internet. The ICDREC is used for teaching and scientific analysis and can increase a physician's personal database of clinical experience.

The above mentioned WWW applications, an international thyroid database [16], and the ICDREC indicate the benefits of central medical case history repositories. They seem to be good means to support training and research. Important is the access via the Internet to assure wide availability of the data. The questions of how to assure the intellectual property rights of the contributors have not been solved, yet. Pure hypertext seems to be not adequate for representing and exploiting a case history repository due to limited data definition and data retrieval possibilities. Applying CGI in the context of HTTP could overcome this problem. Implementation of a user interface with CGI calls would be complex and slow. The data transfer characteristics of the dialogue oriented human-computer interaction via narrow bandwidth connections is not optimal. Specialized clients have been implemented in Microsoft® Visual C++ to achieve low dialogue response times. The implementation of the user interface in JAVA™ seems to be an even better alternative because it combines the advantages of the WWW and an object-oriented language.

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